Physics Studies with ATLAS, Part II
Discovery of new Physics at The LHC start-up

Davide Costanzo

Event Rates for 2 10^{33}

Process	Events/s	Events on tape for 10 fb^{-1}
$W \rightarrow e\nu$	15	10^8
$Z \rightarrow ee$	1	10^7
$t\bar{t}$	1	10^6
$\tilde{g}\tilde{g}$ m= 1 TeV	0.001	10^4
Minimum bias	10^8	10^7
$b\bar{b} \rightarrow \mu X$	10^3	10^7
QCD jets p_T>150	10^2	10^7

assuming 1% of trigger bandwidth

A lot of interesting studies will be possible right after start-up

Saturday 24 May 2003

SUSY (09:00->11:15)

Chair: Paige, F. and Polesello, G.
Location: Athens University

09:00	**Introduction** (15') (transparencies)	**Polesello, G.** *(INFN Pavia)*
09:15	**Full simulation studies: introduction** (20') (transparencies)	**Paige, F.** *(BNL)*
09:35	**Full simulation studies: results I** (25') (transparencies)	**Costanzo, D.** *(LBL)*
10:00	**Full simulation studies: results II** (25') (transparencies)	**Tovey, D.** *(Sheffield University)*
10:25	**A new technique for inclusive studies** (15') (transparencies)	**Duchovni, E** *(Weizmann)*
10:40	**Slepton searches** (15') (transparencies)	**Lytken, E.** *(NBI Copenhagen)*
10:55	**Stop searches** (20') (more information)	**Kawagoe, K.** *(KOBE University)*
11:15	Coffee break	

Exotics (11:45->13:20)

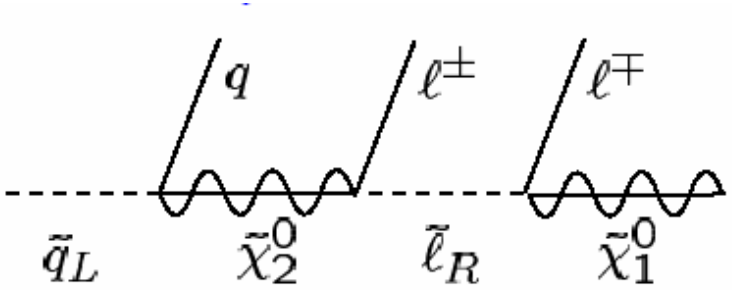
Chair: Azuelos, G. and Poggioli, L.
Location: Athens University

11:45	**Introduction** (15') (transparencies)	**Azuelos, G., Poggioli, L.**
12:00	**Search for Heavy Leptons** (20') (transparencies)	**Alexa, C.** *(Bucarest/CERN)*
12:20	**Kaluza-Klein excitations of gauge bosons** (20') (transparencies)	**Polesello, G.** *(Pavia)*
12:40	**Black Hole production and decay** (20') (transparencies)	**Parker, A.** *(Cambridge)*
13:00	**Search for Black Holes** (20') (transparencies)	**Tanaka, J.** *(Tokyo)*
13:20	**Search for Z' and heavy quarkonia** (10')	**Kozlov, G.** *(Dubna)*
13:30	Lunch	

SuperSymmetry

- Large $\tilde{q}\tilde{q}, \tilde{q}\tilde{g}, \tilde{g}\tilde{g}$ cross-section $\rightarrow \approx$ 100 events/day at $2 \cdot 10^{33}$ for $m(\tilde{q}, \tilde{g}) \sim 1$ TeV

Typical SUSY decay chain:



SUSY Signatures:

-Missing Et (from Neutralinos)

-High Pt Jets

-High Pt Leptons

-Invariant Mass End-Points

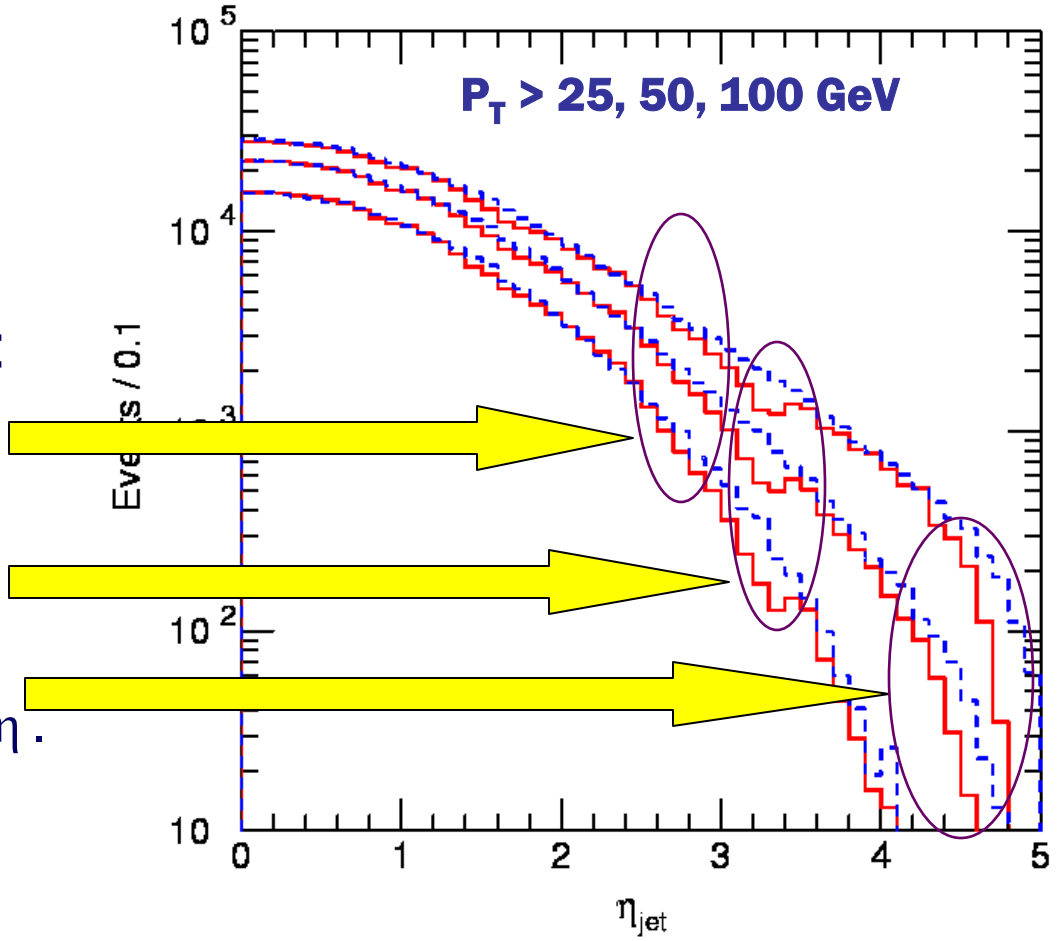
SM Background normally negligible

A sample of 10^5 Events Simulated with Geant as part of ATLAS Data Challenge 1
Corresponding to ~ 5 fb^{-1} of data

Useful to understand many aspects of the ATLAS performance

Jet Reconstruction:

- Simplest test → distribution of Truth and Detector jets as function of η.
- Some problems evident:
  - Barrel-Endcap Crack
  - Loss of Detector jets in Endcap-Forward crack
  - Shower leakage at large η .

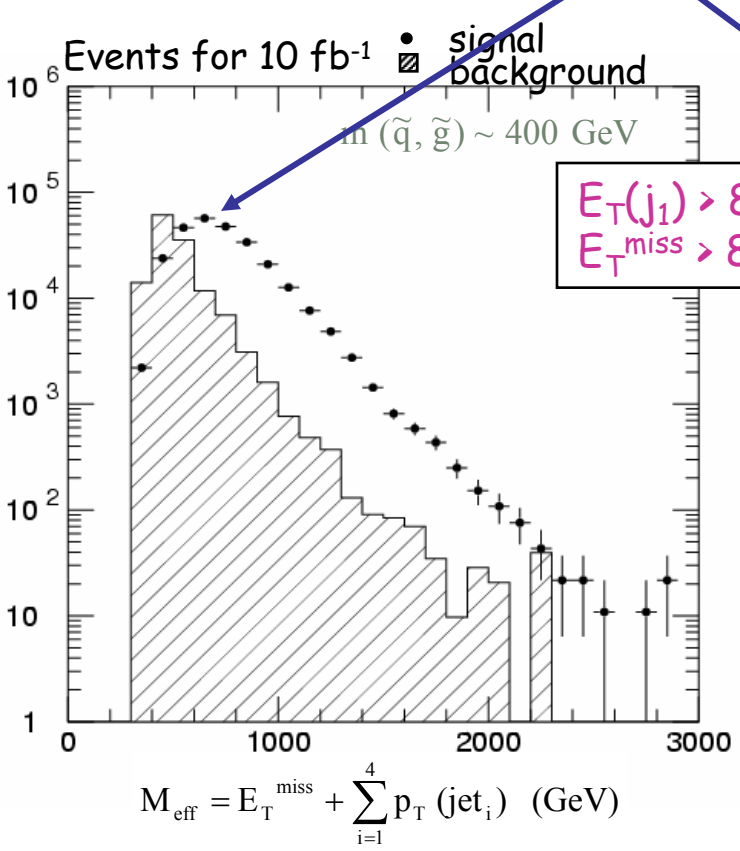


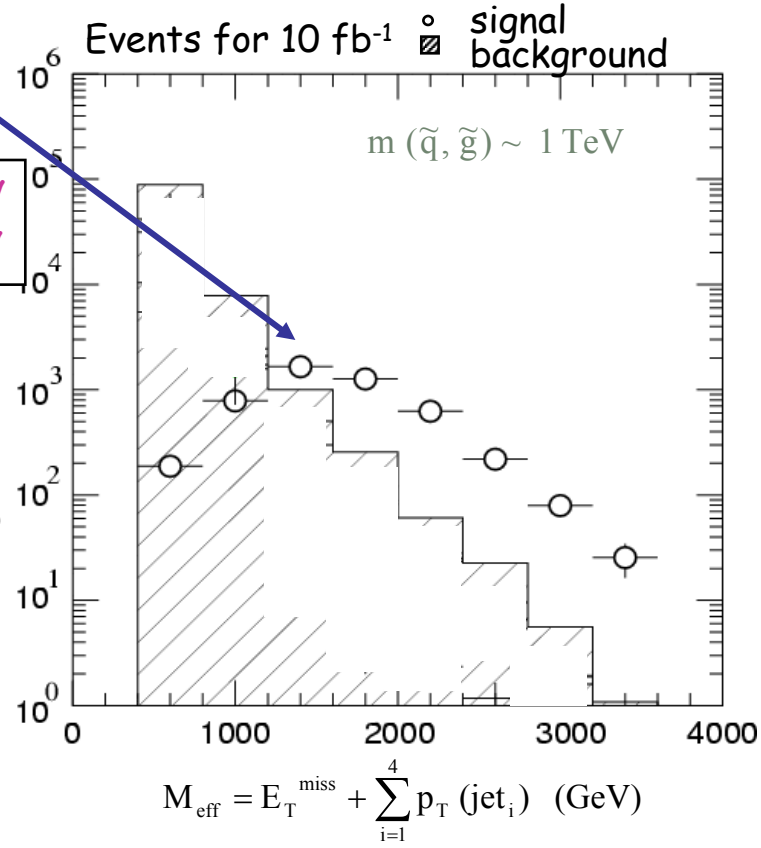
SUSY: Inclusive Analysis

- Multijet + E_T^{miss} is most powerful and model-independent signature (if R-parity conserved)

$$M_{eff} = P_{t,1} + P_{t,2} + P_{t,3} + P_{t,4} + \not{E}_T$$

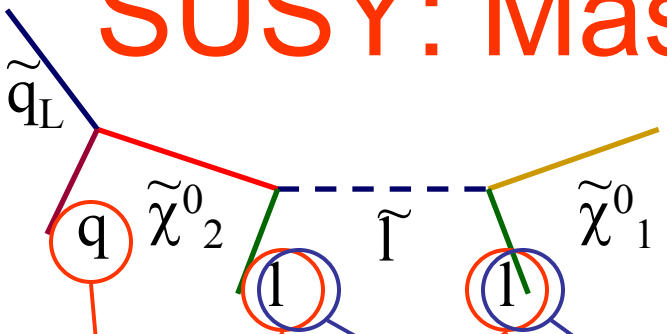
Peak position correlated to $M_{SUSY} \equiv \min(m(\tilde{q}), m(\tilde{g}))$

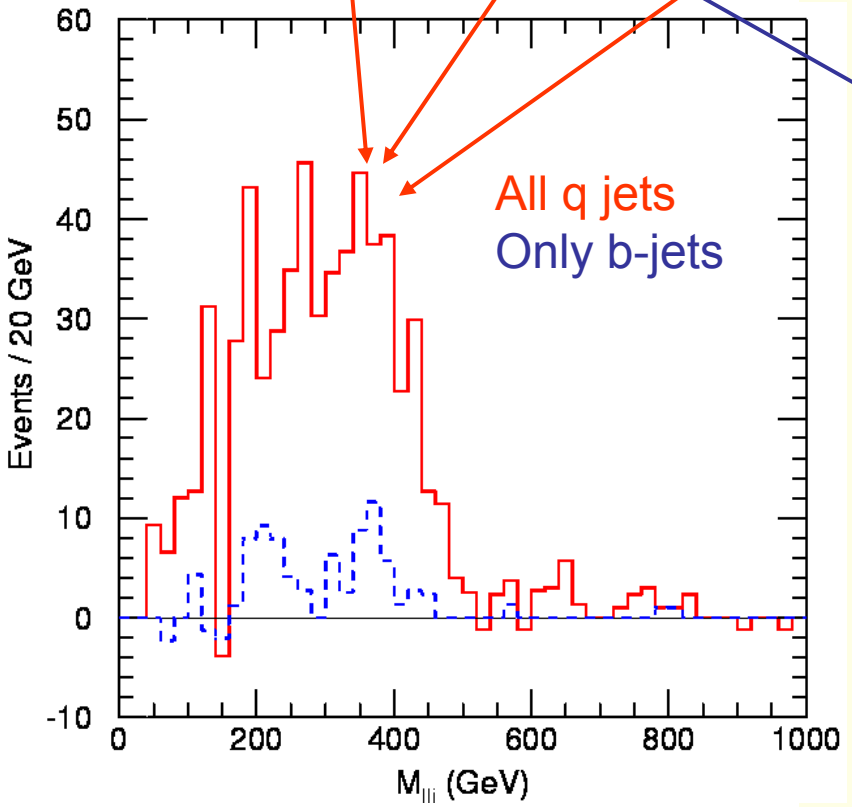


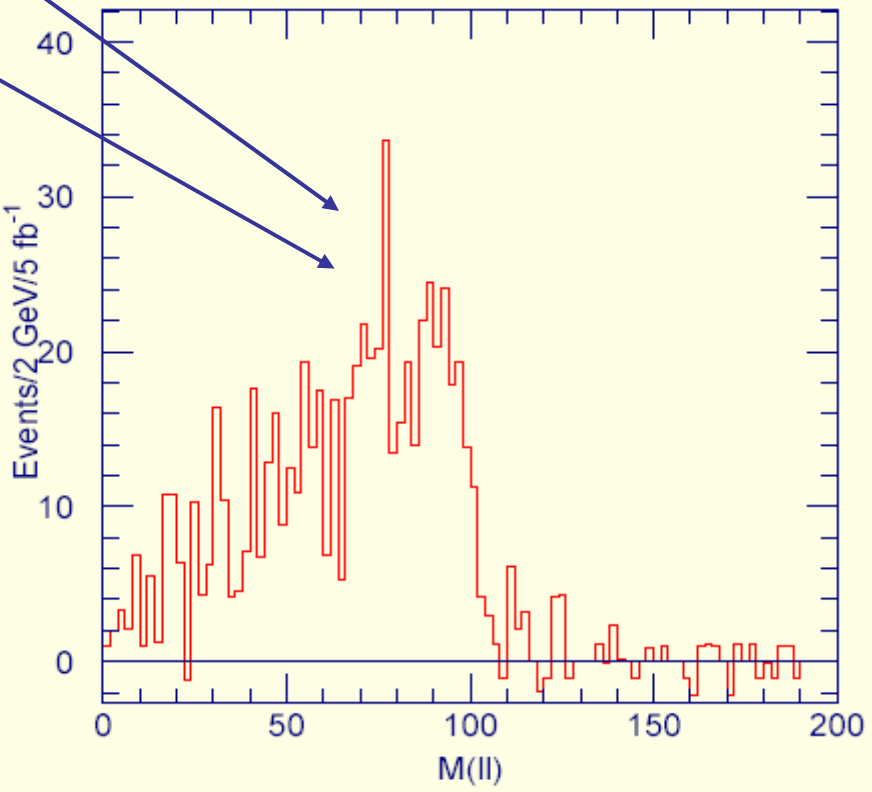


From M_{eff} peak, first/fast measurement of SUSY mass scale to ≈ 20%

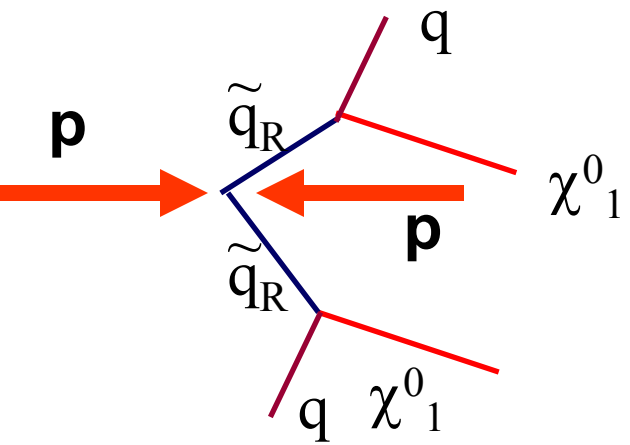
SUSY: Mass Edges

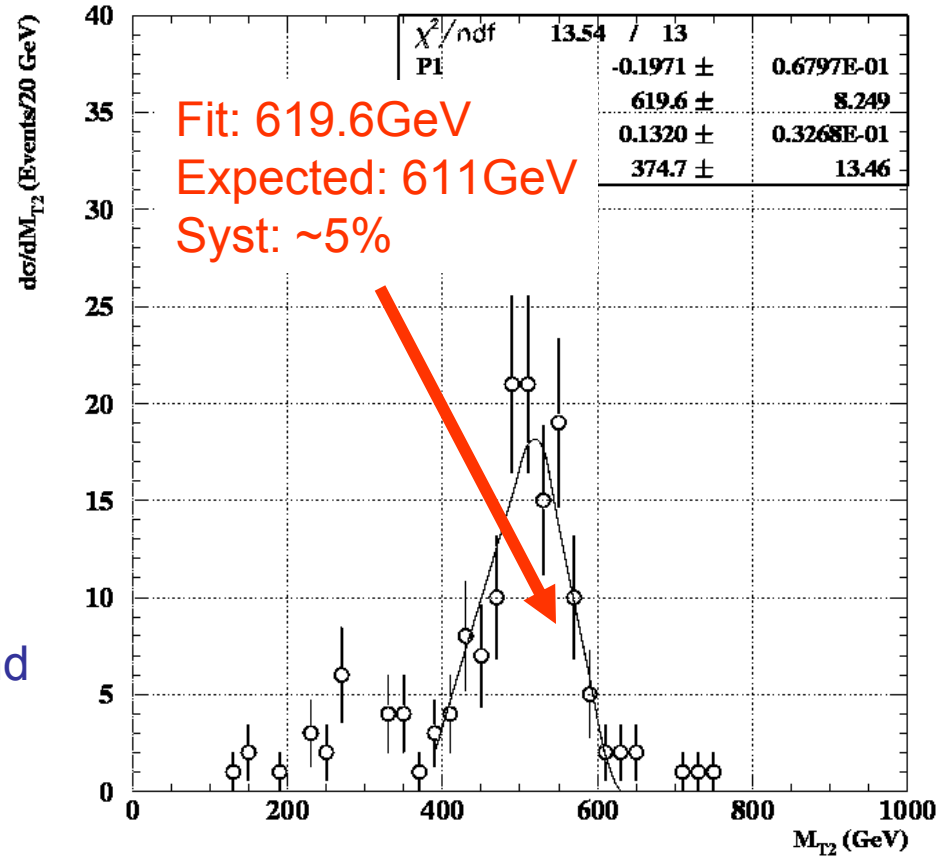






$\tilde{q}_R$ Mass Measurement



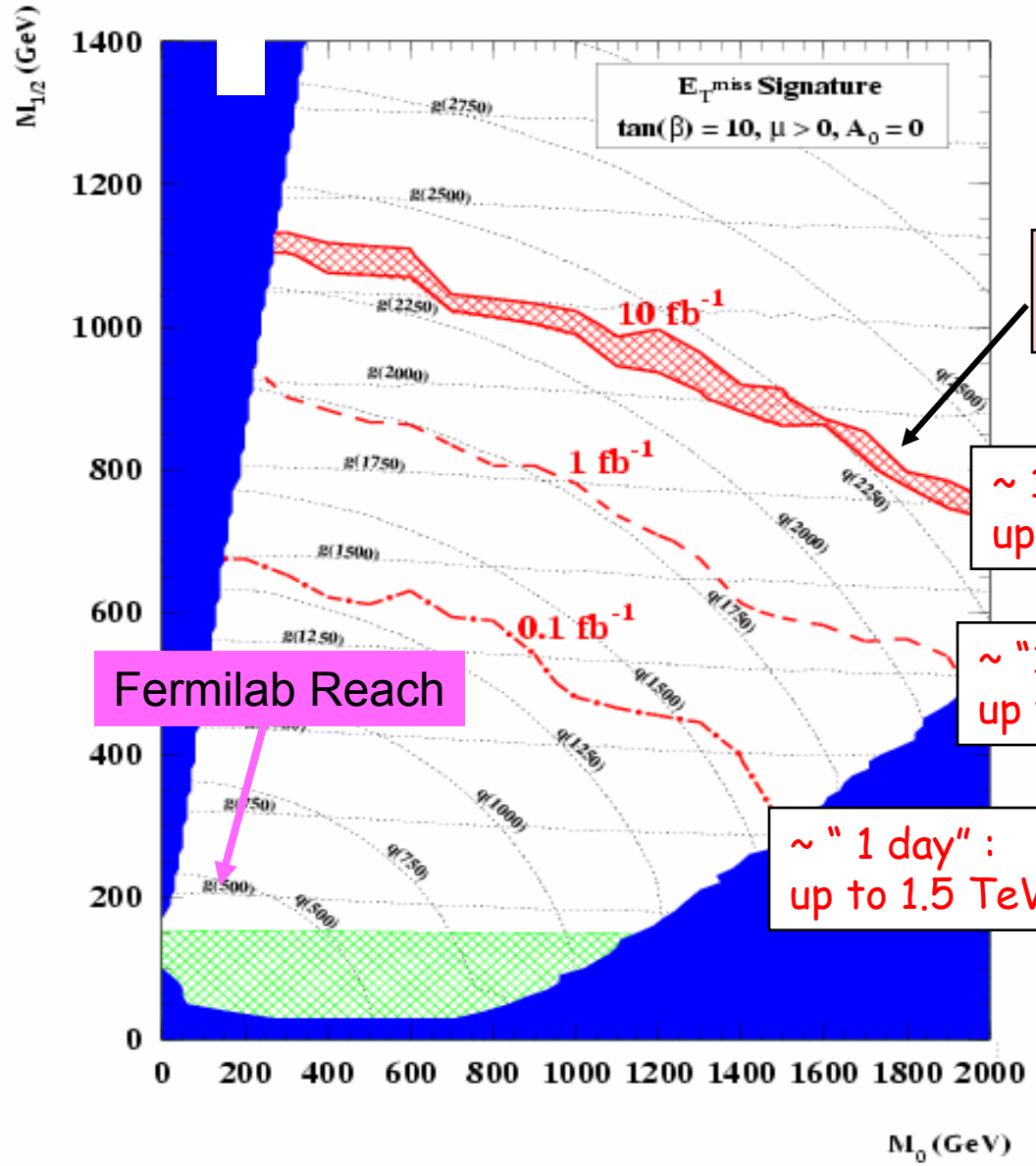


Select Events with two jets (>100GeV) and Missing E_T (>200 GeV)

Define "s-tranverse mass" as:

$$m_{T2}^2 = \min_{q_T^{\chi(1)}+q_T^{\chi(2)}=E_T^{miss}} [\max\{m_T^2(p_{Tj(1)},q_{T\chi(1)};m_\chi), m_T^2{}_{(pTj(2)},q_{T\chi(2)};m_\chi)\}]$$

SUSY: Discovery Reach



ATLAS
5σ discovery curves

band indicates factor ± 2 variation in background estimate

~ 100 days :
up to 2.3 TeV

~ "10 days" :
up to 2 TeV

~ " 1 day" :
up to 1.5 TeV

Precision measurements of SUSY masses:
Point 5 and 100 fb-1:
Mass of q_L : 3%,
Mass of χ_1: 12%

SUSY "Discovery" Tools

Relevant issues for early discovery:

-- enough pre-scaled lower-threshold triggers to normalize Background

-- quality of $E_T$miss measurement (calorimeter inter-calibration, cracks)

Cracks can be monitored with $Z (\rightarrow l^+l^-)$ + jets

Background process (examples ….)	Control samples (examples ….)
$Z (\rightarrow \nu\nu)$ + jets $W (\rightarrow \tau\nu)$ + jets $t\bar{t} \rightarrow bl\nu bjj$ QCD multijets	$Z (\rightarrow ee, \mu\mu)$ + jets $W (\rightarrow e\nu, \mu\nu)$ + jets $t\bar{t} \rightarrow bl\nu\ bl\nu$ lower E_T sample

(Comenius University)

13:00	Lunch	

Higgs (14:00->17:00) — **Chair:** Cerutti, F. and Richter-Was, E. — **Location:** Athens University

14:00	**Introduction** (15') (transparencies)	Richter-Was, E. (CERN and JU/INP Cracow)
14:15	**Search for ttH with H->bb** (15') (transparencies)	Cammin, J. (Bonn)
14:30	**Search for ttH with H->WW and H-> tau tau** (15') (transparencies)	Tanaka, R. (Okayama Univ.)
14:45	**Higgs searches in the Vector Boson Fusion channels** (20') (transparencies)	Mellado, B. (Wisconsin)
15:05	**Search for H-> gamma gamma: inclusive vs N-jet tag** (15') (transparencies)	Unal, G. (LAL and ParisXI)
15:20	**H -> 4 muons: most recent full simulation studies** (15') (transparencies)	Nicolaidou, R. (CEA-Saclay)
15:35	**Update of SM Higgs discovery potential** (10') (transparencies)	Cerutti, F. (LNF and INFN)
15:45	**Measurement of the Higgs boson parameters** (20') (transparencies)	Duehrssen, M. (Mainz)
16:05	**Updated MSSM scan** (20') (transparencies)	Schumacher, M. (Bonn)
16:25	**Searches for MSSM Higgs bosons in tau final states** (15') (transparencies more information)	Dosil, M. (Barcelona)
16:40	**Search for invisible Higgs decays** (15') (transparencies)	Gagnon, P. (Indiana)
17:00	End	

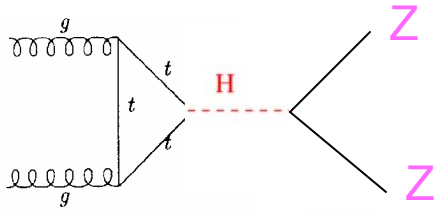
Excursion to Cape Sounion (17:00->21:00) — **Location:** Athens University

Saturday 24 May 2003

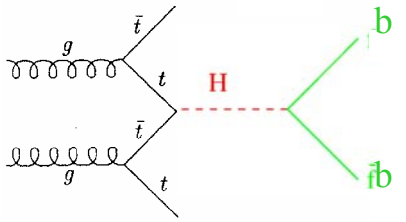
SUSY (09:00->11:15) — **Chair:** Paige, F. and Polesello, G. — **Location:** Athens University

Higgs Channel by Channel

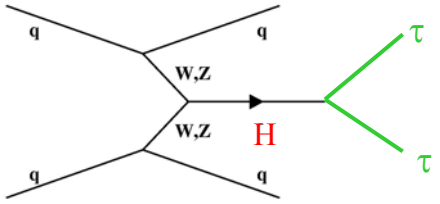
$H \rightarrow ZZ$

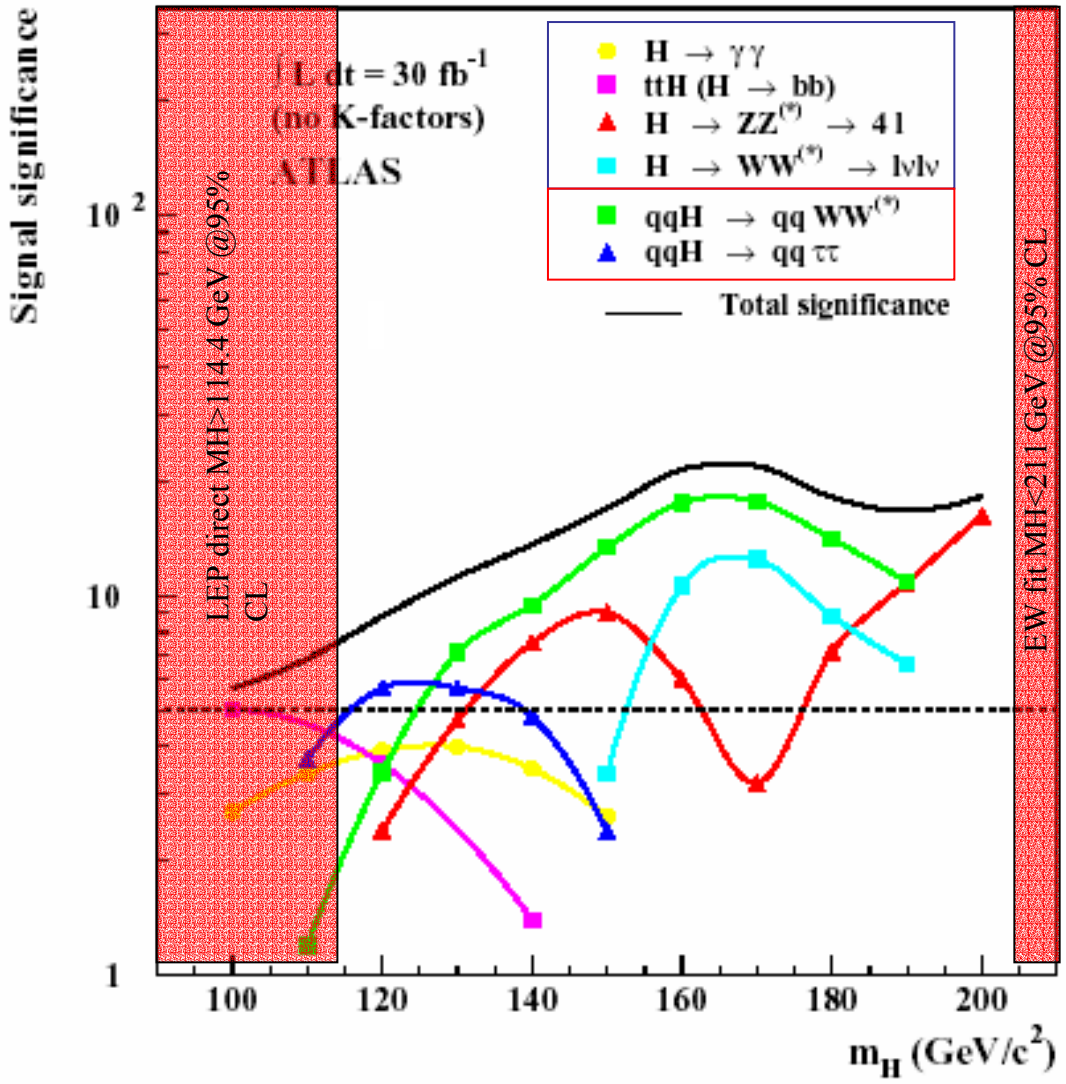


$ttH \rightarrow tt\ bb \rightarrow bl\nu\ bjj\ bb$



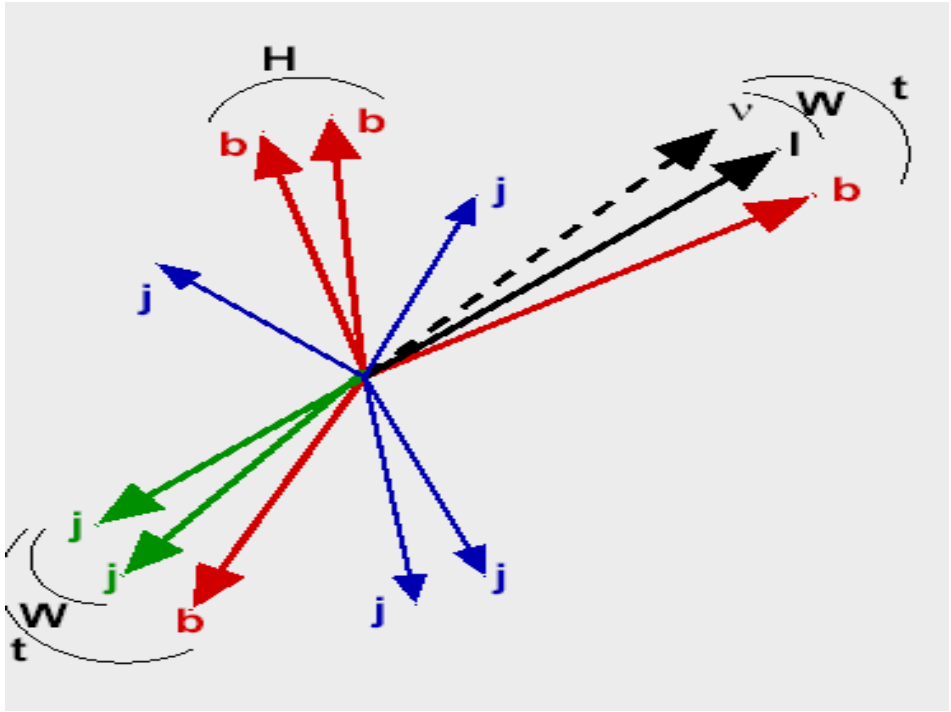
$qqH \rightarrow qq\tau\tau$





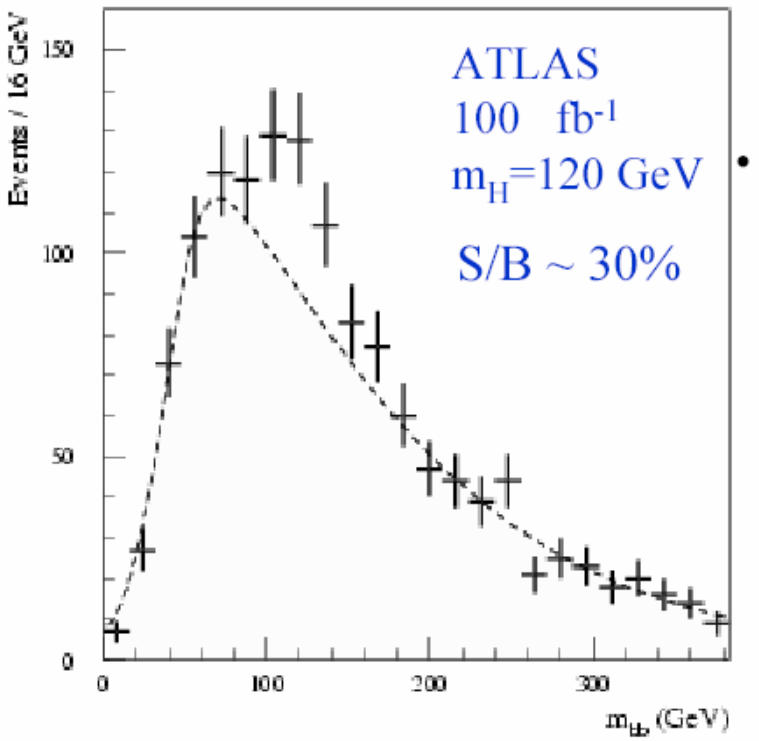
Example 1: ttH

Topologically difficult to Reconstruct:



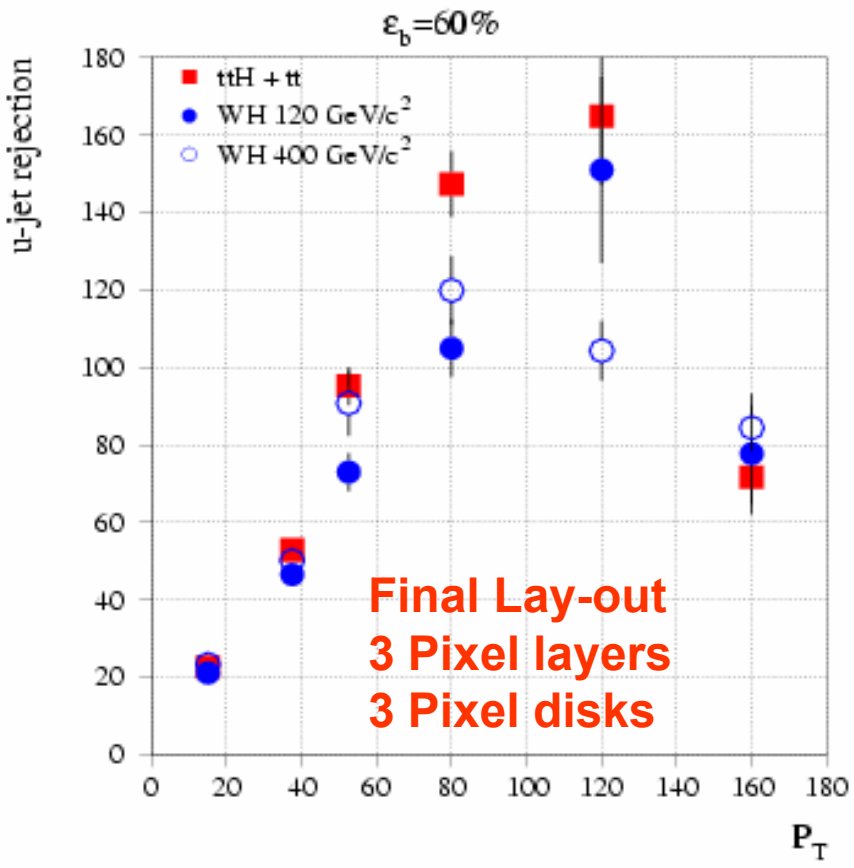
Tagging efficiency is Critical (4 b-jets)

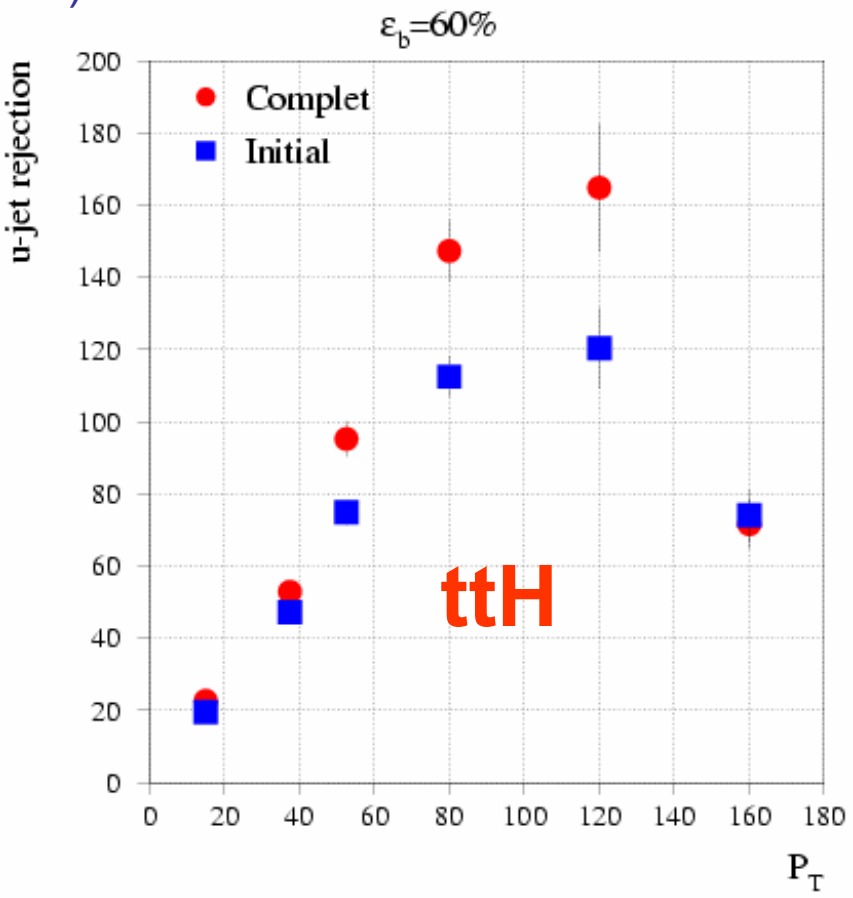
Rejection against light quark jets important (ttjj << ttbb)



b-Tagging Performance

Rejection against light quark jets for ε = 60%
Some degradation for the reduced “Initial layout”
Worse result in SUSY events (work in progress)





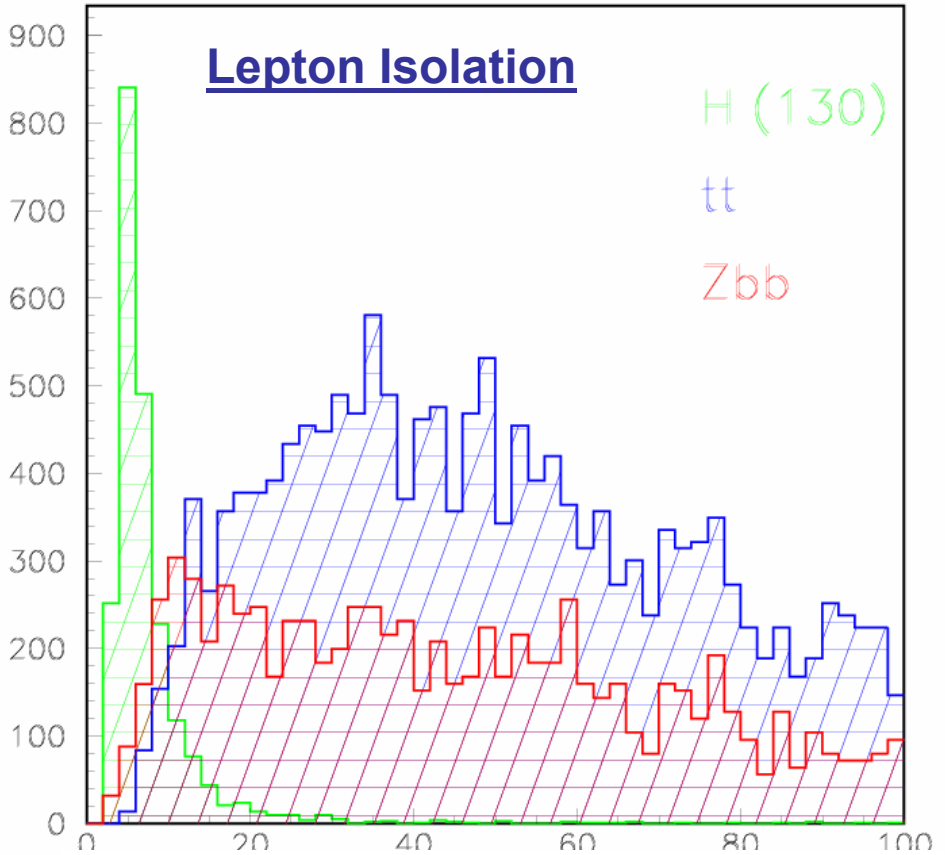
Example 2: H→ 4 leptons

Gold-plated Channel:
4 isolated leptons

Rate limited: BR(Z→ll)^2

Backgrounds:
ZZ*(γ)→4l (irreducible)
Top, Zbb (reducible)

Performance:
Trigger
Lepton Reconstruction
Lepton Isolation
Lepton Impact Parameter



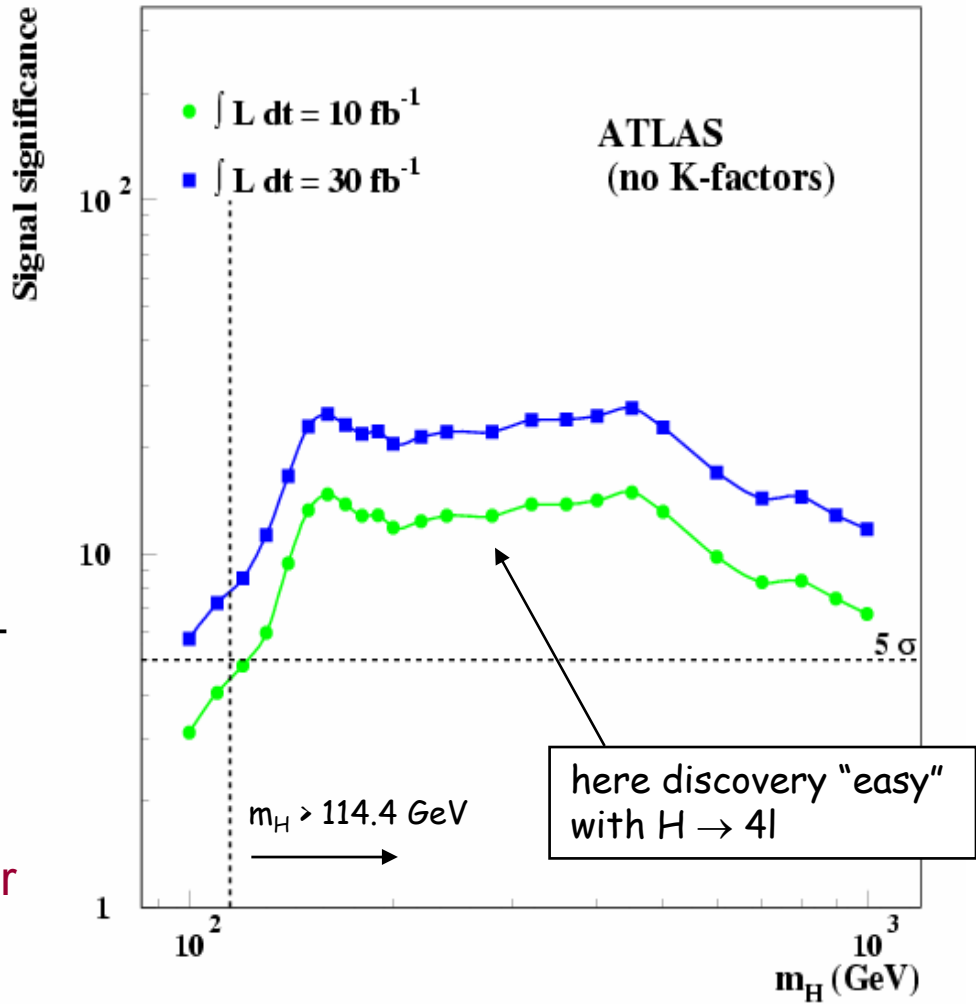
Energy in a 0.2 Cone Around the Lepton

Potential for Higgs Discovery

Different production and decay modes
Different backgrounds
Different detector/performance requirements:
-- ECAL crucial for H $\rightarrow \gamma\gamma$
-- b-tagging crucial for ttH
-- efficient jet reconstruction over $|\eta| < 5$
crucial for qqH $\rightarrow$ qq$\tau\tau$:

ALL require:
-- "low" trigger thresholds.
E.g. ttH analysis cuts : pT (l) > 20 GeV, pT (jets) > 15-30 GeV

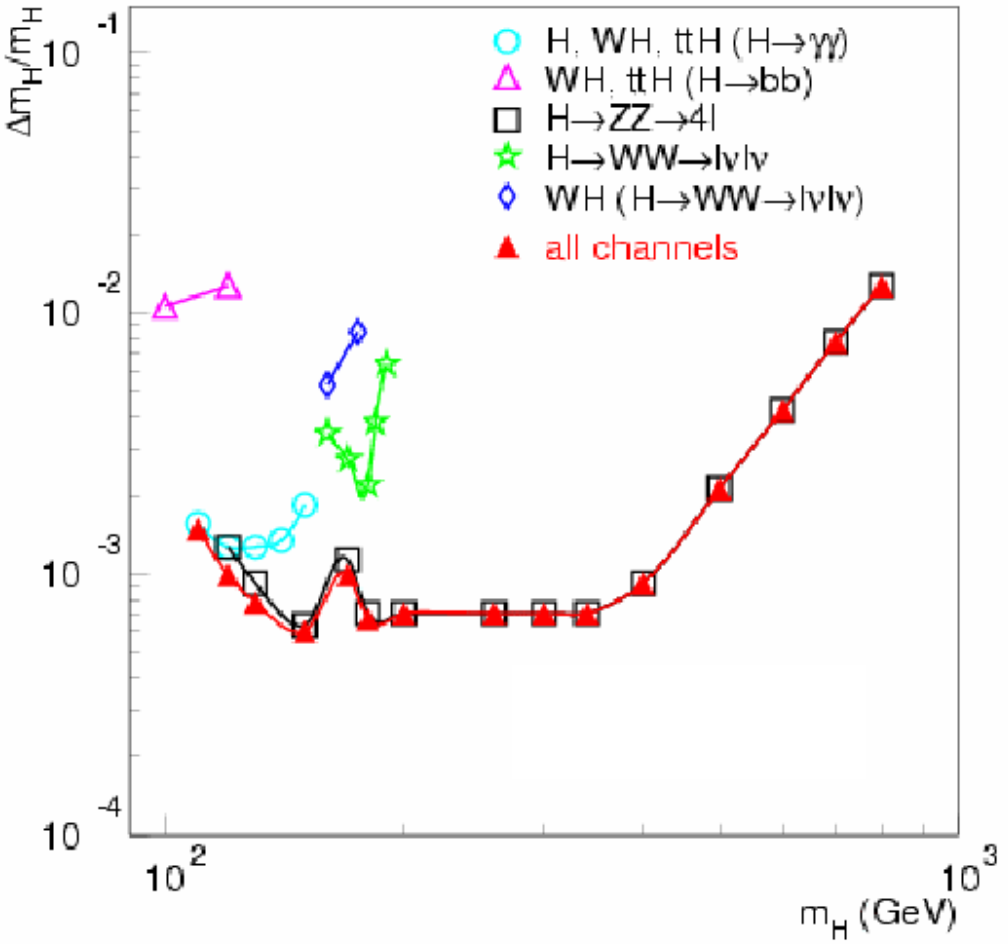
-- very good understanding of backgrounds, given the tiny signals and/or the small S/B



Higgs Precision Measurements

A precise (0.1%) measurement of the Higgs mass can be achieved with 300 fb^{-1}

Couplings can be measured
With a ~20% precision



Social dinner in Pireas (21:00->23:30) — **Location:** Pireas

Sunday 25 May 2003

What else ... ? (09:30->12:20) — **Chair:** Gianotti, F. — **Location:** Athens University

09:30	**Physics coverage of trigger: impact of deferrals, pre-scaled/exclusive triggers** (30') (transparencies)	**Tapprogge, S.** *(HIP Helsinki)*
10:00	**GEANT4 for HEP detectors simulation** (25')	**Apostolakis, J.** *(CERN)*
10:25	**Summary of G4 physics validation studies in ATLAS** (25') (transparencies)	**Solodkov, A** *(IHEP Protvino)*
10:50	**Outcome of the "Little Higgs Task Force"** (40') (transparencies)	**Garcia J.-E., Hinchliffe I.** *(IFIC Valencia, LBL)*
11:30	**Astroparticle physics: present status and links to LHC** (30') (transparencies)	**Mavromatos, N.** *(Kings College London)*
12:00	**First thoughts about ATLAS impact on astroparticles** (20') (transparencies)	**Pinfold, J.** *(University of Alberta)*

Conclusions (12:20->13:00) — **Chair:** Dris, M. — **Location:** Athens University

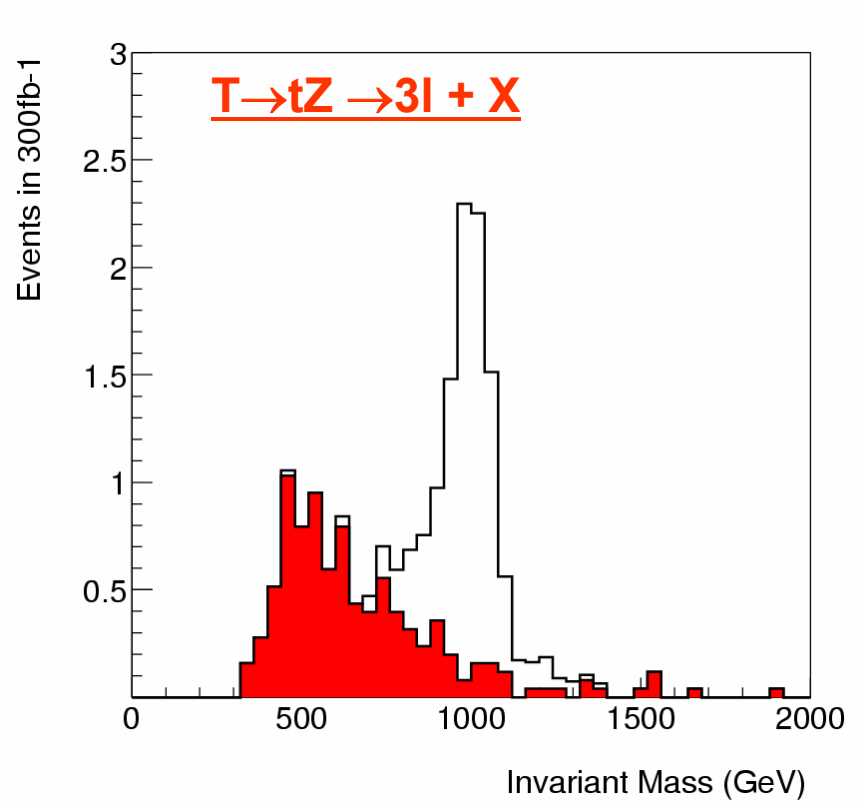
12:20	**ATLAS Scientific Notes** (05') (transparencies)	**Haywood, S.** *(RAL)*
12:25	**Concluding remarks ....** (35') (transparencies)	**Jenni, Gianotti, etc.** *(CERN)*
13:00	End of Workshop	

Little Higgs Model

New Model to deal with the Hierarchy Problem
(phenomenologists at work)

1. T heavy top
2. W_H , Z_H, A_H
3. Higgs triplet ϕ^0 , ϕ^+ , ϕ^{++}

Work is in progress:
ATLAS can cover almost all the allowed parameter space with 300 fb^{-1}



Conclusions

ATLAS has a huge Physics Program to Exploit

SUSY (~ 1Tev mass scale) can be identified with 100pb^{-1}.

Higgs (120GeV) is more difficult, requires at least 10fb^{-1}

Activity has started to understand the “Physics Commissioning” .

We all look forward to the first collisions in 2007!